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Tri-Service Thermal Radiation Test Facility Xenon Flashlamp Operators Manual

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Technical Report

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Safe operating and servicing test procedures for the Flashlamp Thermal Simulator, the Flashlamp Thermal Simulator Voltage Monitor, and the Vortek Stabilized Arc Lamp are described in this document. The manual guides test technicians operating a Bentley 286/8 microcomputer through proper safety and operational procedures while operating the Flashlamp Thermal Simulator and the Vortek Stabilized Arc Lamp. A (pre and post) safety checklist to be followed during equipment utilization is provided. A description of the instrumentation used in support of testing and procedures for servicing are also provided.

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PREFACE

This document incorporates the Flashlamp Controller Operator's Manual developed under Contract No. DNA001-88-C-0083 by Science Applications International Corporation, developers of the Xenon flashlamp system. The operator's manual, written by N. Convers Syeth of SAIC, is still used as the basic manual for facility operation.

In developing a training guide for the safe operation of the Flashlamp Thermal Simulator (FTS), sections regarding safety and additional operating parameters developed since publication of the original SAIC operator's manual have been added.

TABLE OF CONTENTS

SECTION 1
SAFETY

All procedures in the operation of test equipment within the Tri-Service Thermal Radiation Test Facility will be in accordance with the UDR-TR-94-70, "Standard Safety Operating Procedures Manual" which govers all activities within the TRTF.

General

Ear protection should be worn whenever occupying the Data-Acquisition Room 710C (Figure 1.1) or the FTS/VSAL Control Room 701B (Figure 1.1) during operation of Wind Tunnels or when cooling the Flashlamp Thermal Simulator during a test.

Eye protection with a minimum #10 welding filter is used to observe a test but the energy source should never be viewed directly regardless of protection.

No personnel will occupy the Flashlamp Thermal Simulator/Vortek Stabilized Arc Lamp (FTS/VSAL) Room 711 (Figure 1.1) or the Nitrogen Cooling Bank Room 711B (Figure 1.1) when either the FTS or VSAL is being operated. There is the danger of flying glass from a ruptured lamp, high-pressure water from a ruptured hose, exposed high-voltage connections, corrosive chemical from a ruptured capacitor or hot metal sparks from an overheated component or test specimen. The FTS/VSAL Control Room 710B and the Data-Acquisition Room 710C may be occupied by a limited number of personnel during testing. The test may be observed through the smoked acrylic window between Room 710B and 711 but only with adequate filtered eye protection. The doorway between Room 710B and 711 must be kept clear of personnel during FTS/VSAL operation. The doorway between the FTS/VSAL Test Room 711 and the main hallway is interlocked preventing access to 711 from the hall whenever either the FTS or VSAL is energized. The doorway between 711 and the General Storage area Room 712 (Figure 1.1) is kept locked from the 711 side preventing access to 711 from 712 at any time.

The emergency eye wash and emergency laboratory full-body shower (Figure 1.1) are located in the main hallway at the West end near the exit doors that have no windows. The eye wash is activated by a palm-press handle located below and to the right of the bowl and must be held down to cause the water to flow. The full-body shower is a flush

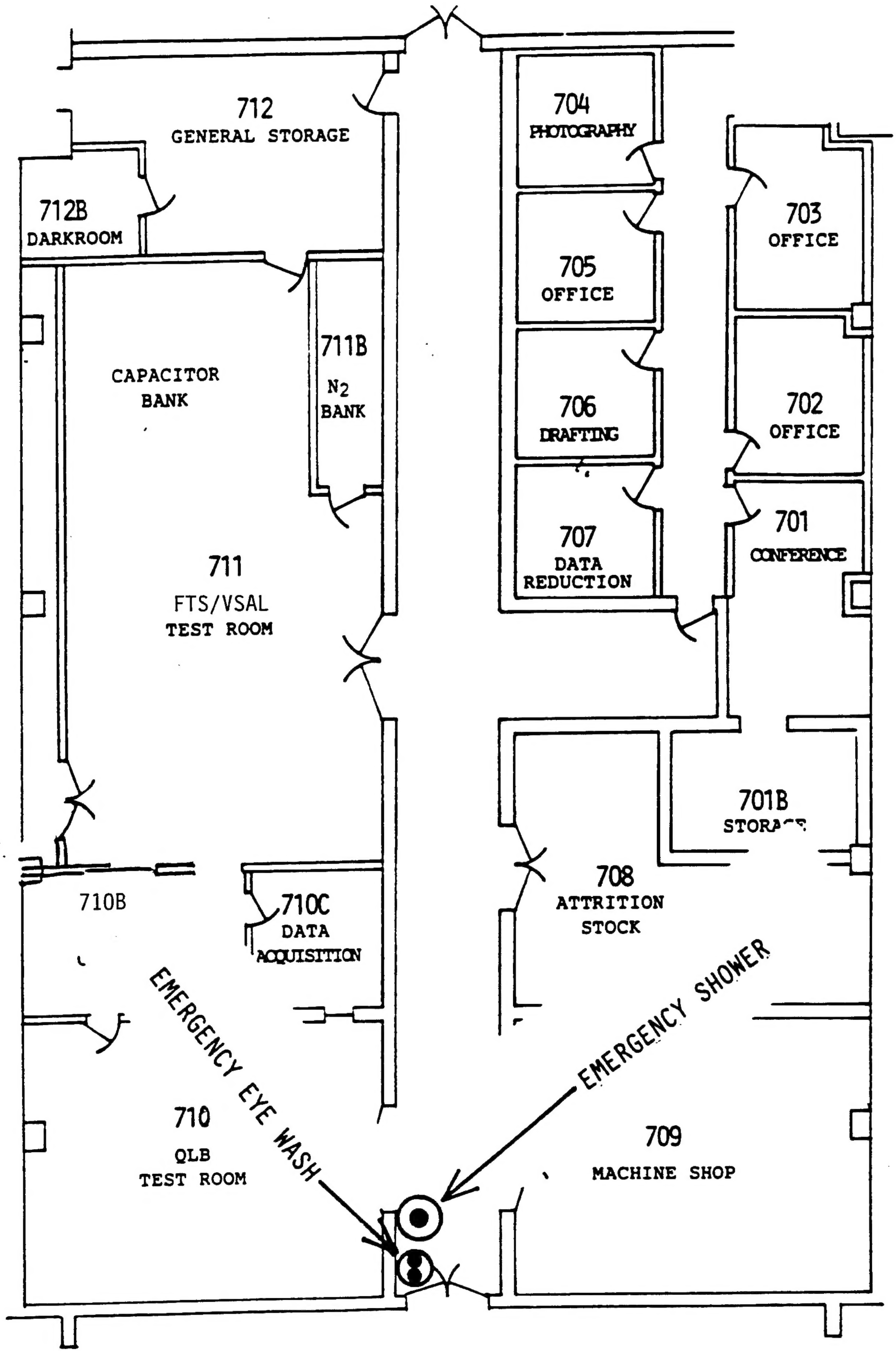

Figure 1.1. Emergency Eye Wash and Shower.

Signs have been posted on the Facility Attic access ladders in the West hall. Authorized personnel assessing the attick area are warned on the possible noise and light that could pass through the ceiling material causing distraction and possible balance loss to personnel in the attic area.

All full-time University of Dayton Research Institute personnel working at or assigned to the Tri-Service Thermal Flash Test Facility shall be trained in the technique of Cardiopulmonary resuscitation (CPR).

SECTION 2

SAIC FLASHLAMP CONTROLLER OPERATOR'S MANUAL

FLASHLAMP CONTROLLER OPERATOR'S MANUAL

N. Convers Wyeth

December 1988

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LIST OF FIGURES & DRAWINGS

1. INTRODUCTION

The Flashlamp Thermal Simulator (FTS) Controller Upgrade consists of a Bentley 286/8 microcomputer (IBM-AT compatible), keyboard, color display, printer, custom interface board, desk, and software. It replaces the old FTS controller unit and handheld controller. Improvements over the old system include the use of off-the-shelf components throughout (except for the custom interface board which uses replaceable, off-the-shelf chips), automatic sequencing and keyboard control of some functions which were previously manual (e.g., high gas, ignitron power, etc.), and the ability to calculate nuclear waveforms and lamp firing times on the controller computer itself. The software is menu-driven and operator-prompting and therefore virtually self-explanatory.

Both the software and hardware of the Controller Upgrade were built with components and designs allowing for later improvements and/or additions such as data acquisition, diagnostics/exercises, etc.

2. START UP: THE MAIN MENU

When the controller computer is turned on, the boot-up sequence includes the automatic loading and running of the controller operating code. With the monitor turned on, the main menu of seven choices appears as shown in Figure 2.1. The shaded selector bar is moved to the desired choice using either set of arrow keys; when using the number pad arrow keys, be sure the number lock ("num loc") function is off. Press the <Enter> key to activate the menu choice. Note that the No. 3 choice (Diagnostics/Exercisers) is not available on this version. No. 7 (Exit to DOS) allows the user to enter the computer's MS/DOS operating system for file management, editing, etc. (see Sections 3.3 and 3.4 below). After exiting to DOS, the controller operating code can be restarted by rebooting the computer or (when in the DNA directory) by typing "dna" (without the quotation marks) and hitting <Enter>.

Starting the operating program causes all of the control outputs to be initialized to their proper settings. However, if the interface board is turned on (power switch on right desk front) with the computer off or the operating program not running, certain of the output control lines (e.g., DAS trigger, ignitron triggers 1-93) may be in the "on" state. This should not cause any serious problems because all the important power controls are locked "off" (see Section 5).

```
DNA FLASHLAMP THERMAL SIMULATOR

**** MAIN MENU ****

1 - Calculate nuclear waveform
2 - Synthesize pulse shape
3 - Diagnostics/Exercisers
4 - Calibration shot
5 - Fire VSAL only
6 - Fire pulse
7 - Exit to DOS
```

Figure 2.1. Main menu of the FTS controller operating code.

3. COMPUTATIONAL FUNCTIONS

3.1 Calculate Nuclear Waveform

When this option from the main menu is chosen, a DNA-supplied program called "MORE" is activated. Use of this code is self-explanatory with an extensive "HELP" file. While this program can perform a number of useful calculations concerning nuclear weapons effects, its primary reason for inclusion here is to calculate thermal flux versus time curves from a set of input parameters such as height of burst, yield, distance, atmospheric conditions, etc. The user chooses a name for the data output from a calculation, and when the thermal time history plot data file for the specified parameters is generated, it will use the chosen name with the file extension ".hot". The sequence of menu choices to produce thermal flux data files is as follows (see Figure 3.1). Choose No. 2 (calculations) from the main MORE menu and enter the input parameters called for. When the next calculation selection menu appears, choose No. 6 (Generate plot data files), and from the succeeding plot option menu, choose No. 2 (Thermal time history plots).

The user can view (and print) a graph of this flux versus time curve before exiting "MORE". Several thermal flux data files can be created in one session on "MORE", each with a different name and all with the extension ".hot". The names should be noted by the user so that they can be recalled for simulation by the FTS after

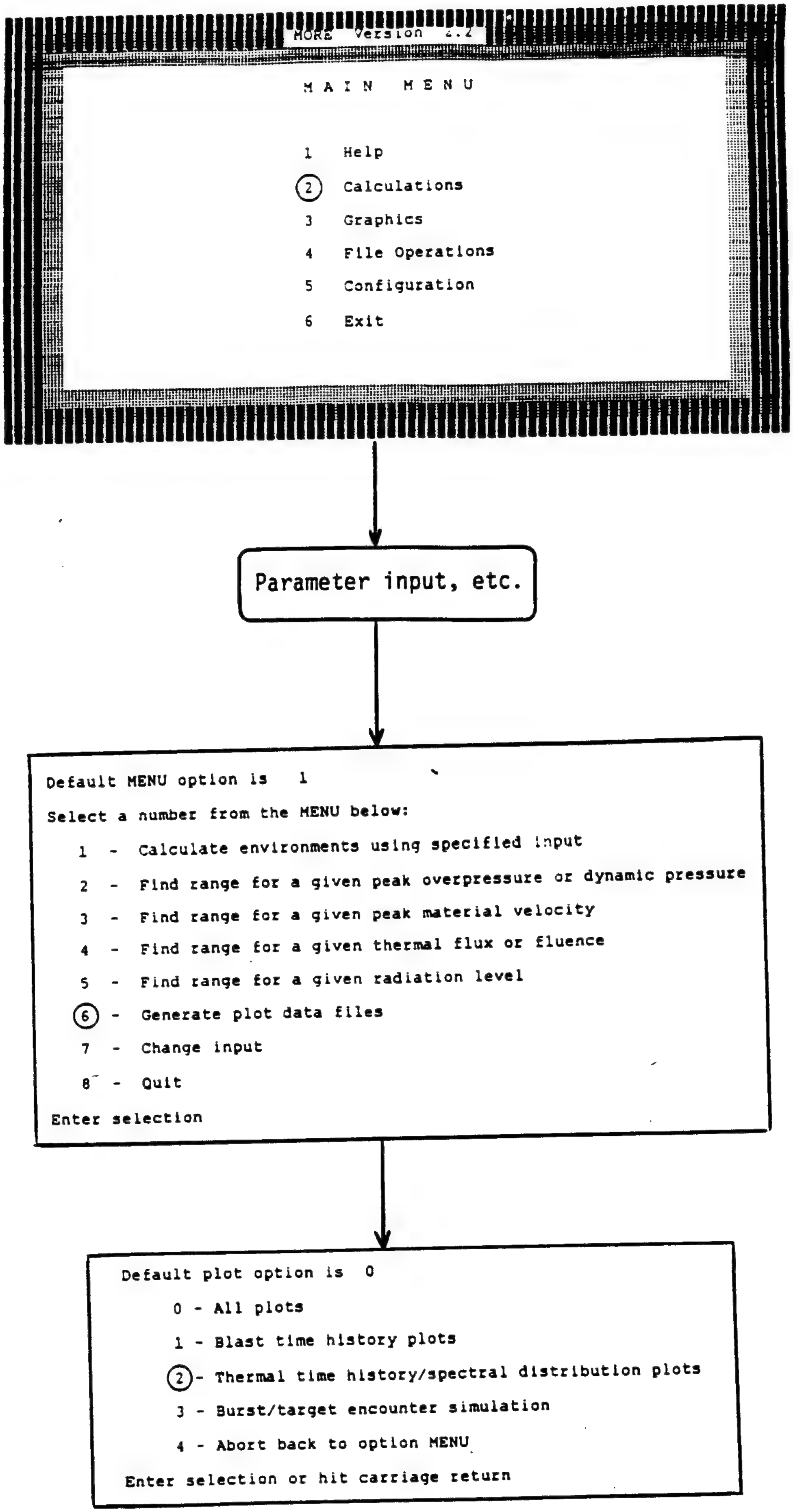


Figure 3.1. Sequence of menu choices to produce thermal flux curves using the MORE program.

returning to the main menu.

3.2 Synthesize Pulse Shape

This main menu option is used to activate a sub-program in the controller code which accepts a flux versus time file as input and calculates the optimum flashlamp firing times, bank voltage, and flux multiplier to simulate the flux curve. The firing times will be stored for later use in operating the FTS (see below), the bank voltage is set by the operator, and the flux multiplier is the factor (≤ 1.0) by which the standard (reflector exit plane) output of the FTS must be reduced in order to reproduce the desired flux curve (this reduction is usually achieved by moving the sample away from the exit plane).

The flux data file must meet the following criteria:

- Number of lines: 1-250
- On each line: time in seconds, flux in cal/cm^2-sec with both values in floating point format, no other format requirements
- Range: time - begin with 0, no greater than 10
  flux - no greater than 2000
- Increments: the increment between successive time values must be constant
- File Name and Location: must have extension ".dat" and be stored in subdirectory C:\DNA\DAT, or can be ".hot" file created in "MORE" (see Sections 3.1 and 3.3).

The "Synthesize Pulse Shape" routine starts by displaying a list (with dates) of all files in the DNA/DAT subdirectory and the ".hot" files in "MORE" (see Figure 3.2). When an acceptable file name is chosen from the displayed list, a graph of the flux-time curve contained in the file is displayed (including the calculated total fluence, peak flux, and time of peak), and the operator is asked if this is the correct curve to be simulated. A negative response causes a return to the main menu, while a positive response evokes a second query regarding changing the maximum flux multiplier setting to a value less than one (the default value). If the nature of the test requires that the thermal flux be used (or the test object be placed) at some distance from the FTS reflector exit plane, a maximum value less than one can be specified for the flux multiplier, where this maximum value corresponds to the minimum distance allowed.

Once the flux multiplier has been set (or the default value chosen), the code begins to calculate the lamp firing times, bank voltage, and flux multiplier value needed to best simulate the flux curve. This calculation cannot proceed unless a file listing the lamp efficiency factors is stored properly in the computer.

```
DNA FLASHLAMP THERMAL SIMULATOR

            Flux Files
      SQUAREPU.DAT   9-15-88
      MAXF.DAT      11- 7-88
      SAMPLE2.HOT    7-22-87
      SAMPLE4.HOT    7-22-87
      SAMPLE3.HOT    7-22-87
      SAMPLE1.HOT    7-22-87
      NUC9.HOT       9-21-88
      NUC1.HOT       9-20-88
      NUC2.HOT       9-21-88
      NUC3.HOT       9-21-88

Use 'Home' and 'End' keys to move selection
 bar to desired file name, then hit 'Enter'.
```

Figure 3.2. Display of flux file selection list.

The following is a general description of how this pulse synthesizing algorithm works. The guiding criteria for the calculation are:

- The bank voltage is as low as possible - this reduces lamp wear and allows more pulses to be used which can make for a smoother output curve.
- The flux multiplier is as low as possible (subject to the bank voltage being minimized) - this also allows more pulses to be used.
- Refire limitation - a given lamp cannot be fired again until the refire time has elapsed since its last firing, with the refire time given by:

  $$\tau_r(\text{sec}) = (3.33 \times 10^{-5})V^2 + 0.159$$

  where V is the firing (bank) voltage.
- Adjacency limitation - a given lamp cannot be fired if any of its nearest neighbors were fired within the previous 40 msec. This is to prevent induction effects from an operating lamp on one that is being started.
- The lamps are fired no faster than one per millisecond in a fixed order (up to three times) with the starting point in the sequence chosen to put a particular section of the firing order around the flux curve maximum (the latter approach is used because the nearest neighbor firing spacing varies throughout the sequence).

The algorithm procedure begins by using the total fluence of the desired pulse shape to calculate first-cut values for the bank voltage, flux multiplier, and number of lamp pulses. This is done by using the total fluence contribution for each lamp and finding the minimum voltage and minimum flux multiplier (the former having

precedence over the latter) for which up to 93 pulses can supply all of the required fluence. If the total fluence demand exceeds the simulator maximum, the algorithm proceeds anyway using the maximum voltage and maximum flux multiplier values. With the initial values for voltage and flux multiplier now set, the total fluence of the first lamp in the firing order is calculated, and integration of the desired pulse shape (flux curve) is begun at time zero and steps forward in one millisecond intervals. When the integrated fluence under the curve reaches one half the fluence of the first lamp, the firing time of this lamp is set at 20 msec <u>before</u> that time to which the integration of the curve had proceeded. The standard FTS lamp pulse shape has produced one half of its fluence approximately 20 msec after pulse initiation (firing). Thus this procedure matches the midpoint of a lamp pulse fluence contribution with the fluence midpoint of the flux curve segment which it is simulating. The total fluence of the next lamp in the firing order is calculated, and the flux curve integration is continued until the integrated fluence <u>minus</u> the total fluence of all lamps already fired equals one half of the next lamp's fluence and so on. After each lamp firing time is set and before the calculation proceeds, the refire and adjacency limitation criteria (see above) are checked for the lamp just fired. If either criterion is violated (i.e., the lamp is to be fired too soon), the algorithm halts the flux curve integration process and attempts to raise the fluence output per lamp in order to increase the time between lamp firings and remove the criterion violation.

The first choice for increasing lamp fluence is to increase the flux multiplier (in practice, this means moving closer to the FTS reflector exit plane). If the flux multiplier value is not already set at its specified maximum, it is increased by a factor roughly proportional to the firing time lengthening required, and the integration through the flux curve pulse shape to determine firing times is begun again starting at time zero. If the flux multiplier is already at its specified maximum, the second choice for increasing lamp fluence is to increase the bank voltage. Although increasing the bank voltage increases the refire time (τ_r), the increase in lamp fluence (proportional to the voltage squared) is proportionally greater than the increase in τ_r because of the constant term in the equation for τ_r (see above). Therefore, increasing the bank voltage does increase the fluence available from one lamp with multiple firings (at the shortest refire time) over a given time interval. If the bank voltage value is not already set at its specified maximum, it is increased by a factor roughly proportional to the firing time lengthening required (taking account of the quadratic dependencies involved), and the integration through the pulse shape is begun again at time zero.

If the algorithm is unable, due to either a lamp firing time limitation violation or running out of fluence (i.e., more than 93 pulses required), to integrate through the entire pulse shape with both the flux multiplier and the bank voltage at their maximum values, the truncated simulation is presented (see below). For

certain fast-rising, very high peak flux pulse shapes, the simulation may truncate after fewer than eleven lamp firings due to the adjacency limitation. This occurs because the flux curve requires that the lamps be fired very rapidly, one after another, and the standard firing order comes back to an adjacent lamp after about 8 lamp firings on average and has several places where only 6 firings separate adjacent lamps. For these special cases, the algorithm switches to a different firing order which allows at least 11 lamps to be fired in rapid succession while sacrificing any chance of proceeding much further along the pulse shape.

When the pulse synthesis is finished, the lamp output flux curve is displayed with the flux curve for comparison, and the operator is asked whether the synthesis is acceptable. If accepted, the generated lamp firing order table (FOT) is stored as a file with the extension ".FOT" in the subdirectory C:\DNA\FOT. The FOT file contains the bank voltage, flux multiplier, and lamp firing times needed to synthesize the pulse. It also contains a coded checksum which the pulse firing function (see Section 4.3 below) will detect. This is to prevent firing order tables not generated by this code (with its restrictions on adjacency and refire times) from being used to operate the FTS.

The operator can also produce a printed record of the flux curve and FTS synthesis as shown in Figure 3.3.

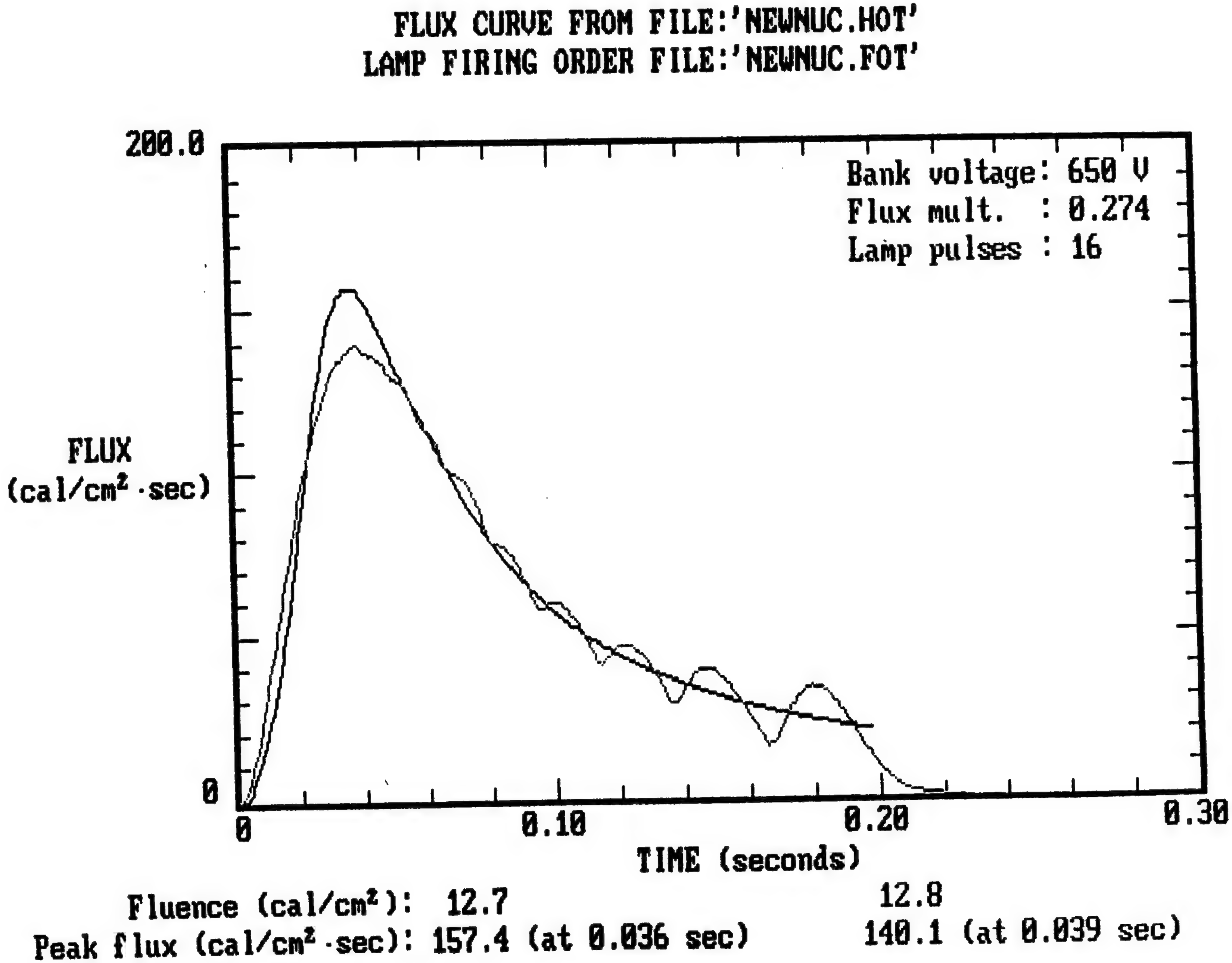


Figure 3.3. Example of the printed record of a flux curve and its calculated FTS synthesis.

3.3 Other Flux Files

User generated flux files may be used with the FTS controller provided they meet the criteria listed at the beginning of Section 3.2 above. They can be created using a text editor such as "Program Editor 4.1" from WordPerfect Corp. (supplied with the controller; see next section) or read from a floppy disk and then stored in the subdirectory C:\DNA\DAT. Flux files not satisfying the criteria will be rejected by the pulse synthesis sub-program.

3.4 Lamp Efficiency File

In order for the pulse synthesis routine to calculate how much fluence each lamp will contribute when fired, a table of lamp efficiencies must be available. The efficiency value for a given lamp is a decimal fraction between 0 and 1 which indicates how much of its theoretical thermal output flux reaches the exit plane of the reflector. Typical values usually range from 0.15 to 0.40 depending on lamp position, lamp age, and condition of the reflector surface. Because the last two quantities change with time, the lamp efficiencies must be remeasured periodically (see Section 4.1 below) and the table updated.

The table is stored as the file "lamp.eff" in the DNA subdirectory (the working directory for the main program, dna.exe). It contains 31 lines, each line consisting of an integer representing the lamp number and a decimal fraction (floating

point) giving the corresponding efficiency. The file can be updated as follows. Exit the main program to DOS (Option No. 7 on the main menu). Then type "PE lamp.eff" and hit the <Enter> key. This will call up the Program Editor (Version 4.1 from WordPerfect Corp.) to edit the "lamp.eff" file. After the editor program loads, the file itself appears. The function key F3 can be used for help in using the Program Editor, but updating this file is relatively simple. Simply use the arrow keys to move the cursor through the file lines, and typeover (or delete and add) the new efficiency values for each of the 31 lamp numbers. When this is completed, hit the function key F7 to exit the editor, and answer the editor's exit questions (bottom line on the screen) so as to replace the old efficiency file with the new version just created.

After exiting the editor, type "dna", and hit the <Enter> key to restart the main controller program.

4. OPERATIONAL FUNCTIONS

The "Control-Break" key combination can be used to abort the controller program at any point. It will initiate an abort sequence which should shut off all systems. <u>However since the controller has little direct feedback, observe all controls with care during any such abort and be prepared to manually correct any problems</u>.

4.1 Calibration Shot

To measure the individual lamp efficiencies (see Section 3.4 above), the peak flux of each lamp when fired at a known voltage must be measured at the reflector exit plane. The formula for the peak flux ($\dot{Q}_{peak}$) in cal/cm^2-sec is

$$\dot{Q}_{peak} = (1.11 \times 10^{-3})\ V^2\ f\ \eta_L$$

where V is the lamp firing (bank) voltage, f is the flux multiplier, and η_L is the lamp efficiency. Since f is unity at the exit plane (by definition), the lamp efficiency is found from the measured peak flux and voltage as

$$\eta_L = \dot{Q}_{peak}/(1.11 \times 10^{-3})V^2.$$

To routinely measure the peak flux of each lamp individually,

the Calibration Shot function causes the lamps to be fired in the order of their numbered positions (note: this is not the firing order during a pulse synthesis shot) at a specified time interval. The 31 lamps can be fired up to 3 times (3 cycles) in a calibration shot in order to use all of the capacitor banks and obtain an average efficiency for each lamp. A calorimeter is placed at the reflector exit plane, and the peak flux for each of the conveniently spaced lamp pulses is recorded.

The controller procedure used to fire the lamps for a calibration shot is very similar to that used in a pulse synthesis shot which is discussed in Section 4.3. The main difference is that instead of choosing a pulse synthesis firing order table (FOT), the operator enters the number of cycles desired (1, 2, or 3) and the lamp firing time interval (50-500 ms) in the window which appears (Figure 4.1).

4.2 Fire VSAL Only

The FTS Controller Upgrade provides the capacity to operate the vortex stabilized arc lamp (VSAL) from the controller keyboard. After choosing this option, the operator is asked for the VSAL pulse duration (up to 60 sec) and the VSAL current level (300-1200 amps). These values are then shown in the upper left corner of the screen for reference, while the operator goes through a prefiring check list (Figure 4.2).

```
DNA FLASHLAMP THERMAL SIMULATOR

                CALIBRATION
Enter the number of cycles...(1,2 or 3)      1
Enter the lamp firing time interval in ms  100
    minimum 1 cycle, maximum 3 cycles
      minimum 50 ms, maximum 500 ms
```

Figure 4.1. Window for entry of calibration shot parameters: number of cycles and firing time interval.

DNA FLASHLAMP THERMAL SIMULATOR

VSAL-ONLY PREFIRING PROCEDURE CHECK LIST

As each item is completed, hit space bar

Inspect VSAL quartz tube, electrodes, & reflector

Check water levels of VSAL cooling systems

Turn on FTS controller board & VSAL main power

Remove VSAL shorting bar

Figure 4.2. VSAL-only prefiring procedure check list.

After these preparations, the operator is prompted to send the standard sequence of commands to the VSAL by using the keyboard spacebar (Figure 4.3). After the initial STANDBY command is sent, the controller pauses for approximately 18 seconds allowing the VSAL to achieve the standby condition. <u>Note that there is no direct feedback to the controller telling it that the VSAL is indeed ready to proceed</u>. When the RUN command is sent, the controller waits to receive a signal from the VSAL that it has gone to full current before displaying "VSAL FIRING". After the specified pulse duration time has elapsed, the controller sends the STOP command to the VSAL. <u>There is no feedback to the controller that the VSAL has actually stopped</u>. <u>Therefore the operator must always be prepared to have the pulse manually terminated from the VSAL control panel</u>.

After the VSAL run is completed, the operator goes through a postfiring check list (Figure 4.4). During the firing sequence, a graphic representation of the VORTEK control panel is shown to inform the operator of the <u>assumed</u> state of the VSAL.

4.3 Fire Pulse

After choosing this function, the operator is shown a list of the stored lamp firing order tables (FOT files) and asked to select one. This collection of files (which is stored in C:\DNA\FOT) should periodically be cleansed of all files older than the present

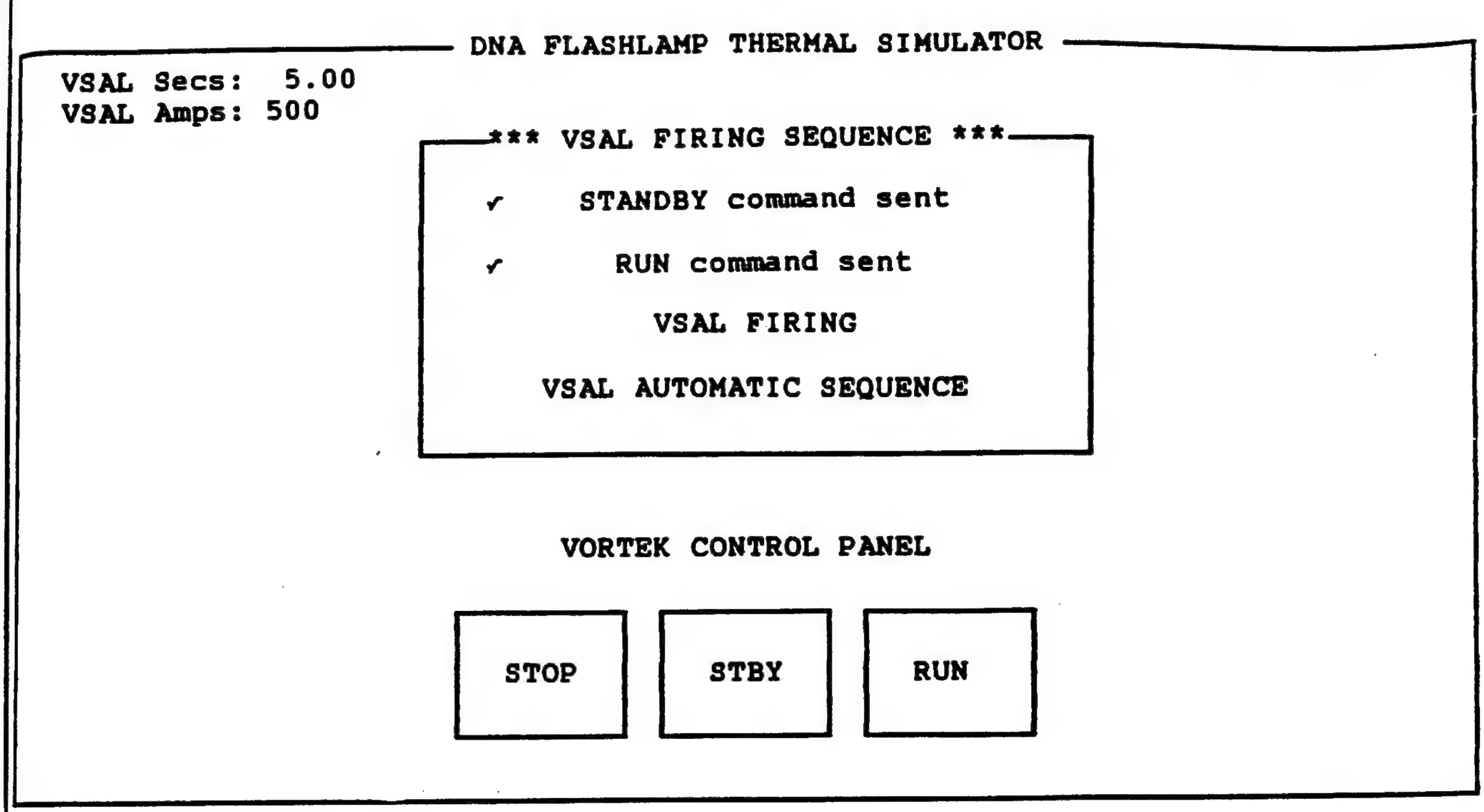


Figure 4.3. VSAL (only) firing sequence.

```
DNA FLASHLAMP THERMAL SIMULATOR
VSAL Secs:  5.00
VSAL Amps: 500
            VSAL-ONLY POSTFIRING PROCEDURE CHECK LIST

                As each item is completed, hit space bar

    ✓  Turn off VSAL main power & replace VSAL shorting bar

       Inspect VSAL quartz tube & electrodes for damage

       Inspect VSAL reflector for damage

       Check VSAL cooling system
```

Figure 4.4. VSAL-only postfiring procedure check list.

lamp efficiency file (see Section 3.4 above) because they will only produce the intended pulse syntheses if the lamp efficiencies have not changed since the FOT files were created.

Next, the operator indicates whether the VSAL is to be operated with the flashlamps. If so, the VSAL pulse duration and current level will be entered after the prefiring check list. Next, the data acquisition time is requested. This time value specifies how long the data acquisition system (DAS) will run after the start of the pulse. If no entry is made, the DAS will never be turned on at the start of the pulse. Next, the operator steps through a prefiring check list (Figure 4.5) which varies slightly depending on whether the run is a calibration shot, a flashlamps-only pulse, or a flashlamps-with-VSAL pulse.

After these preparations, the prefiring sequence (Figure 4.6) of simmering the flashlamps and turning on various power supplies and gas flows is begun. The name of the FOT file, bank voltage, flux multiplier, and VSAL pulse length and current (if needed) are shown in the upper left corner for reference. When the lamps are being started, a schematic diagram of the FTS reflector head appears with the 31 lamp positions shown. The start/simmer process is followed in real time, and the non-starting lamps are listed by number (see Figure 4.7). At this point the operator can proceed and fire the pulse or stop the sequence to replace the faulty lamps. In the latter case, a list of the bad lamps can be printed

(a)

DNA FLASHLAMP THERMAL SIMULATOR

CALIBRATION PREFIRING PROCEDURE CHECK LIST

Inspect flashlamps & reflector

Check water levels of FTS cooling system

Open nitrogen cylinder valves - check cylinder pressure

Make sure FTS controller board is on

Turn on FTS water pump

Charge capacitor banks

As each item is completed, hit space bar

(b)

DNA FLASHLAMP THERMAL SIMULATOR

PREFIRING PROCEDURE CHECK LIST

As each item is completed, hit space bar

✓ Inspect flashlamps & reflector

✓ Check water level of FTS cooling systems

✓ Open nitrogen cylinder valves - check cylinder pressure

Make sure FTS controller board is on

Turn on FTS water pump

Note that flux multiplier is 0.372 for this pulse

Charge capacitor banks to 650 volts for firing

(c)

DNA FLASHLAMP THERMAL SIMULATOR

PREFIRING PROCEDURE CHECK LIST

As each item is completed, hit space bar

✓ Inspect VSAL tube, electrodes, seals & water level

✓ Remove VSAL shorting bar & turn on VSAL power

Inspect flashlamps & reflector

Check water level of FTS cooling systems

Open nitrogen cylinder valves - check cylinder pressure

Make sure FTS controller board is on

Turn on FTS water pump

Note that flux multiplier is 1.000 for this pulse

Charge capacitor banks to 705 volts for firing

Figure 4.5. Prefiring procedure check list: (a) calibration shot; (b) flashlamps-only pulse; (c) flashlamps-with-VSAL.

DNA FLASHLAMP THERMAL SIMULATOR

File: NUC5.FOT
Bank Volt 705
Flux Mult 1.000

*** PRE-FIRE SEQUENCE ***

✓ Simmer sequence complete

✓ Stepper switch homed

✓ Low Gas turned on

✓ High Voltage turned on

✓ Ignitron Power turned on

✓ High Gas turned on

PULSE FIRING CONTROL

Hit fire key to begin firing sequence

Figure 4.6. Pre-fire sequence.

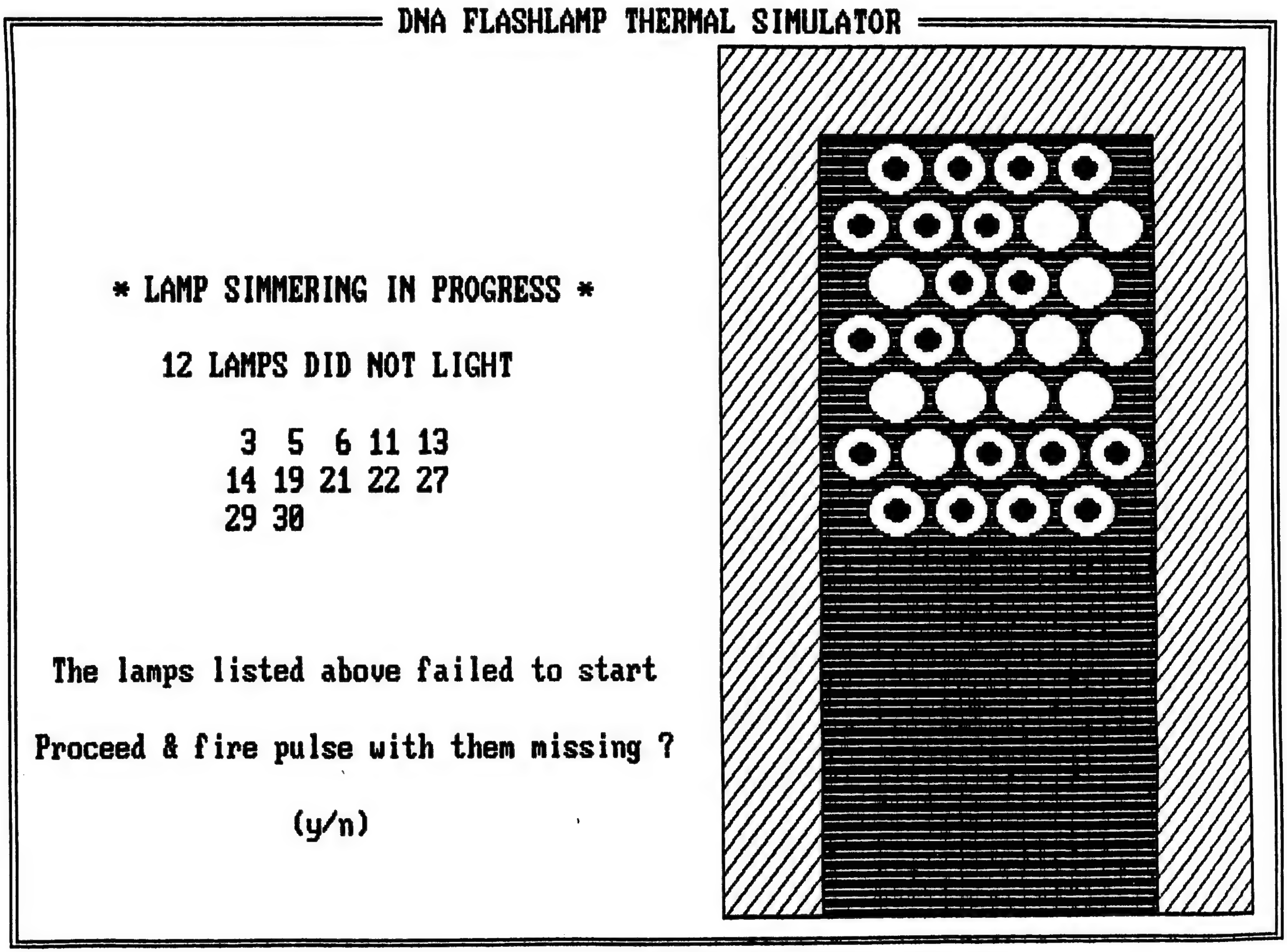


Figure 4.7. Screen display during lamp simmering.

for reference. Toward the end of the prefire sequence, the controller operation takes one of two paths depending on whether the VSAL is included.

For flashlamps only (no VSAL), the prefire sequence is followed by a request for the operator to hit the "fire key" to begin the pulse (Figure 4.6). The fire key is the letter "f" (lower case), and its identity is not revealed by the screen display so that persons who have not read this manual or who are not familiar with the FTS will not know how to initiate a pulse. After the last flashlamp is fired, a shutdown sequence is called for, allowing the operator to turn off the cooling gas flows as the need for them abates (Figure 4.8).

For flashlamps and VSAL, the same fire key hit is requested, but in this case it initiates the VSAL preparation sequence (i.e., STANDBY, delay, RUN) as described in Section 4.2. Here, however, the VSAL sequence proceeds automatically to ensure coordination with the flashlamp firing. The command sequence is shown to the operator as it takes place along with the VORTEK Control Panel graphic (Figure 4.9). Up until just after the RUN command is sent, the operator has a special abort option (compare with Section 4.4 below) available by hitting the space bar. Six seconds after the RUN command is sent, the high gas flow is turned on to just precede the VSAL going to full current. When the VSAL goes to full current (i.e., the beginning of the VSAL pulse), it sends a signal to the

```
DNA FLASHLAMP THERMAL SIMULATOR

File: NUC5.FOT
Bank Volt  705
Flux Mult  1.000

*** SHUT DOWN SEQUENCE ***

✓    High Voltage turned off

✓    Ignitron Power turned off

✓    High Gas turned off

     Turn off Low Gas

     HIT SPACE BAR TO EXECUTE
```

Figure 4.8. Shut down sequence.

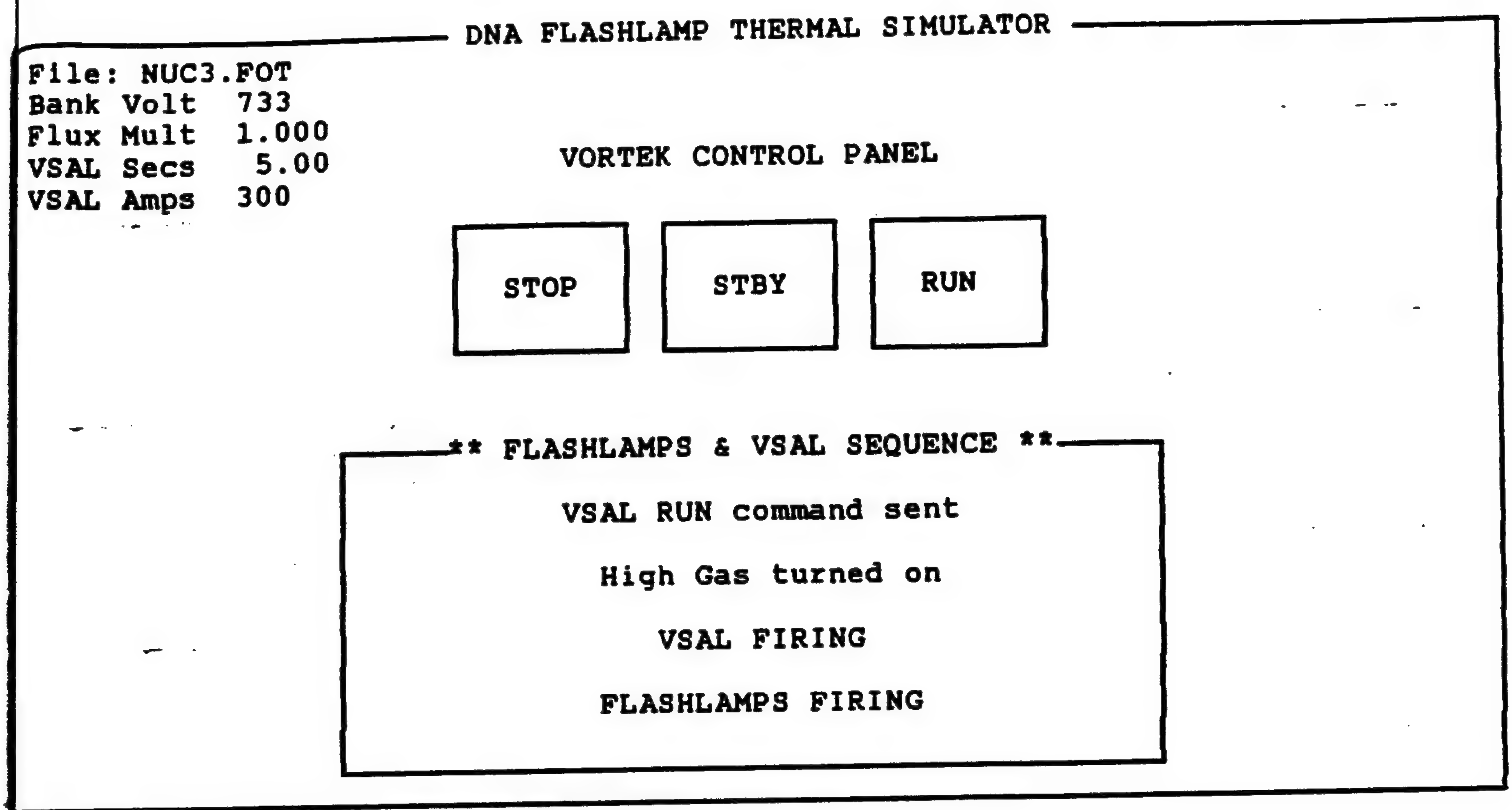


Figure 4.9. Flashlamps and VSAL sequence.

controller which causes the flashlamp pulse sequence to start. The two pulses (flashlamp and VSAL) must be coordinated in this way because the time interval between when the VSAL receives the RUN command and when it goes to full current is indeterminate but at least 6 seconds.

After the last flashlamp is fired or the VSAL pulse ends (whichever is later), the shutdown sequence appears (Figure 4.8). This sequence is followed by a postfiring check list (Figure 4.10). If the DAS time has not elapsed by the time the shutdown sequence is completed, a message appears and the system does not proceed to the postfiring check list until the DAS time has elapsed. Before returning to the main menu, the operator has the option of printing the pulse data window (including the date).

4.4 Manual Overrides

The FTS Controller has only a few direct feedback signals from the system it is controlling. Besides sensing the flashlamp simmer currents, it reads the stepper home signal and the VSAL full-current signal. Thus it has no direct information about the state of the VSAL or the state of the various switches controlled electrically (e.g., high gas, ignitron power, etc.). Several of these controls are toggled, so if the controller loses track of the state (on/off) of a control due to manual operation of that control, it may send a signal to turn off the control which will

(a)

DNA FLASHLAMP THERMAL SIMULATOR

CALIBRATION POSTFIRING PROCEDURE CHECK LIST

✓ Inspect flashlamps & reflector for damage

✓ Close nitrogen cylinder valves

Turn off FTS water pump

Take DVM reading - hold is released after next list item

Hit space bar to initiate second MacSym trigger

Check that capacitor banks are discharged

As each item is completed, hit space bar

(b)

DNA FLASHLAMP THERMAL SIMULATOR

POSTFIRING PROCEDURE CHECK LIST

As each item is completed, hit space bar

✓ Inspect flashlamps & reflector for damage

✓ Close nitrogen cylinder valves

Turn off FTS water pump

Take DVM reading - hold is released after next list item

Hit space bar to initiate second MacSym trigger

Check that capacitor banks are discharged

(c)

DNA FLASHLAMP THERMAL SIMULATOR

POSTFIRING PROCEDURE CHECK LIST

As each item is completed, hit space bar

✓ Inspect VSAL quartz tube & electrodes for damage

✓ Inspect flashlamps & reflector for damage

Close nitrogen cylinder valves

Turn off FTS water pump

Take DVM reading - hold is released after next list item

Hit space bar to initiate second MacSym trigger

Check that capacitor banks are discharged

Figure 4.10. Postfiring procedure check list: (a) calibration shot; (b) flashlamps-only pulse; (c) flashlamps-with-VSAL.

in fact turn it on. Therefore, where manual overrides are used, the control program should probably be aborted and restarted.

The "Control-Break" key combination can be used to abort the controller program at any point. It will initiate an abort sequence which should shut off all systems. <u>However since the controller has little direct feedback, observe all controls with care during any such abort and be prepared to manually correct any problems</u>.

5. HARDWARE

5.1 Computer, Internal Boards, and Peripherals

The microcomputer used in the Controller Upgrade is a Bentley 286/8 (IBM-AT compatible) with 40 Mb miniscribe hard disk, 80287-8 coprocessor, 4800 I/O board, EGA card, and color monitor. Also installed in the computer are a DIO216 interface board and a DCC5 timer board from Industrial Computer Source. An Epson FX-86 printer is also included for hardcopy records.

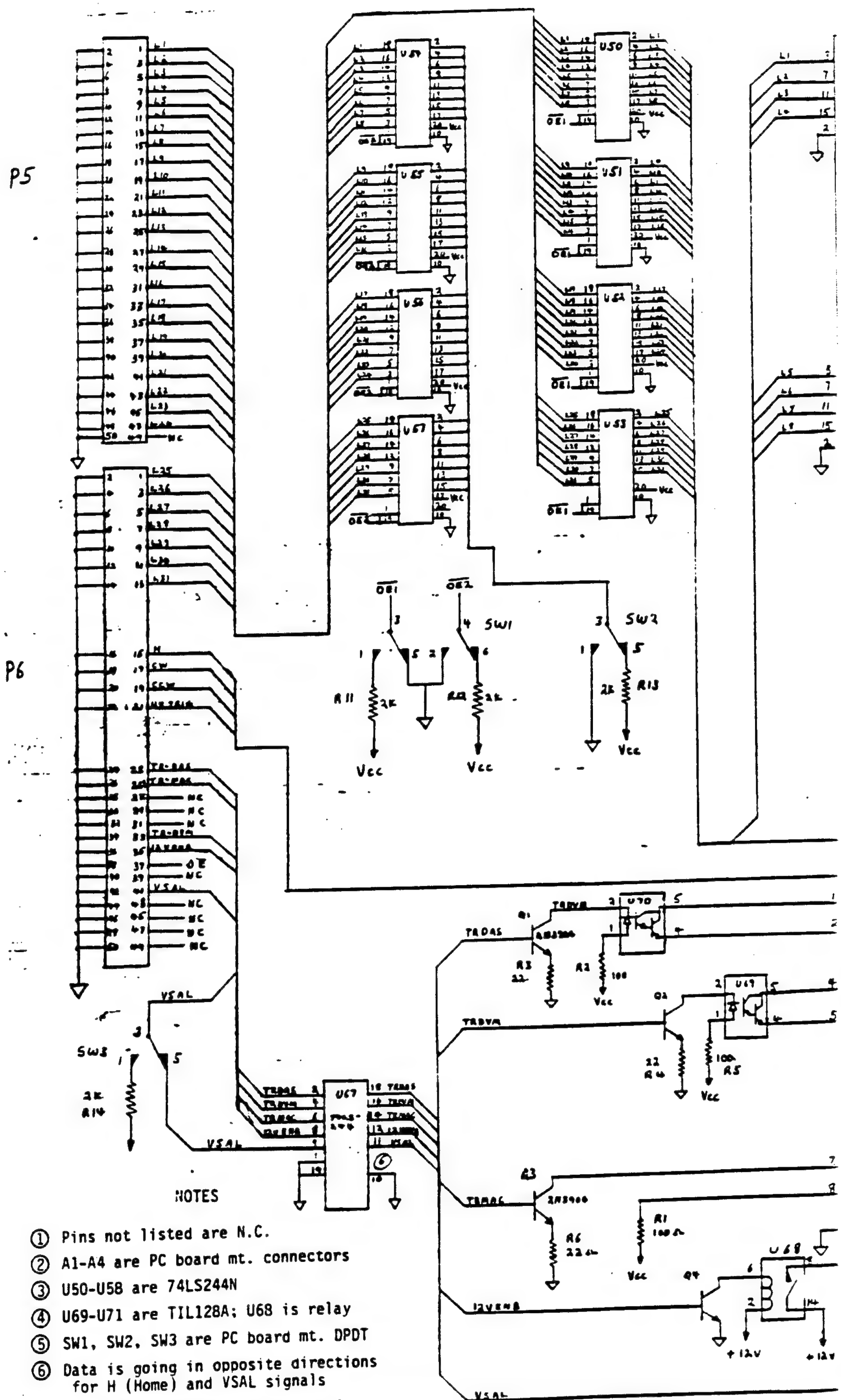
5.2 Custom Interface Board

The computer I/O boards communicate with the FTS by sending and receiving TTL signals from an SAIC-designed custom interface board housed in a slide-out drawer in the controller desk. On this board, the FTS Controller Board (DNA-001-88-C-0083), all signals to and from the computer are buffered through enable-controlled IC's. All signals to and from the FTS pass through opto-isolators to prevent EMI from the high-current, high-voltage FTS system from reaching the controller.

Board mounted reed relays are included to control the high and low gas, high voltage, and ignitron power. Three spare relays were included to allow for future expansion of automated control functions. Three toggle switches were also included in the FTS Controller Board to allow board diagnostics. However, the software

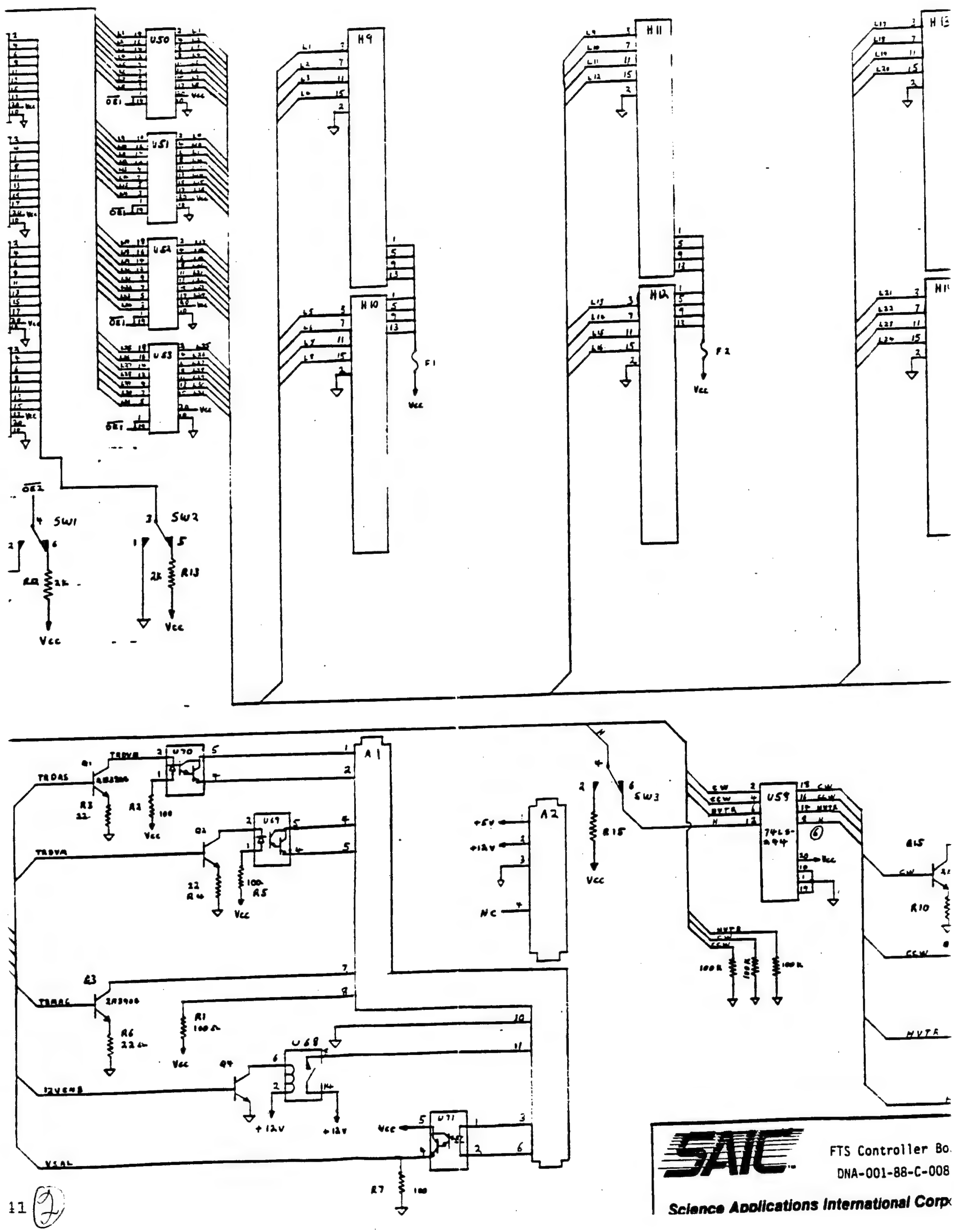
to use these functions is not yet part of the FTS Controller; for normal operation, these switches should remain in the "on" position.

The circuit diagram of the FTS Controller Board is shown in the following three drawings. For further information on the commercial hardware, refer to the individual manufacturers' literature.



NOTES

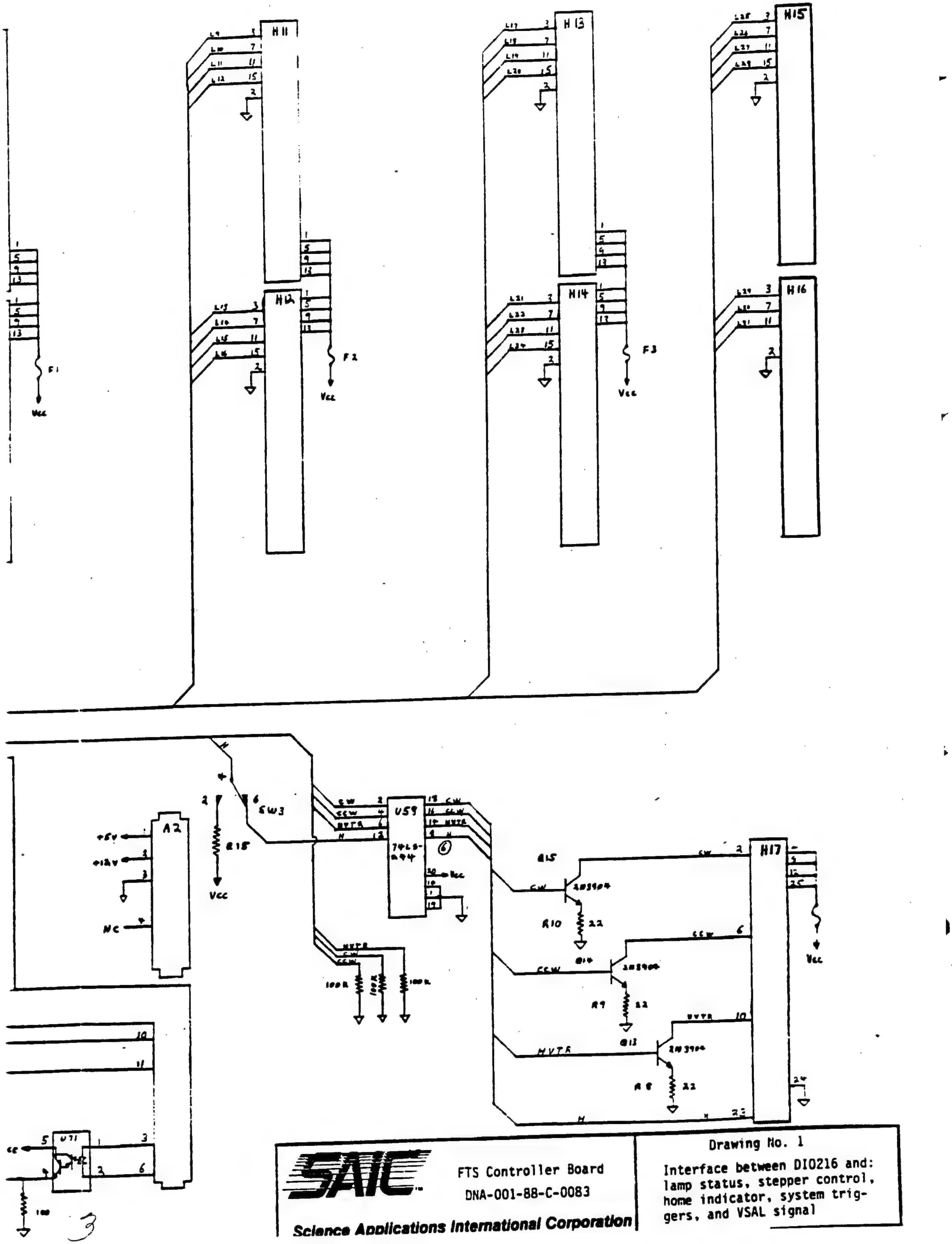
1. Pins not listed are N.C.
2. A1-A4 are PC board mt. connectors
3. U50-U58 are 74LS244N
4. U69-U71 are TIL128A; U68 is relay
5. SW1, SW2, SW3 are PC board mt. DPDT
6. Data is going in opposite directions for H (Home) and VSAL signals
7. All unmarked pins H9-H17 are N.C.
8. All resistance values in ohms
9. SW1, SW2, SW3 ON for normal operation



FTS Controller Bo

DNA-001-88-C-008

Science Applications International Corp



SAIC

FTS Controller Board

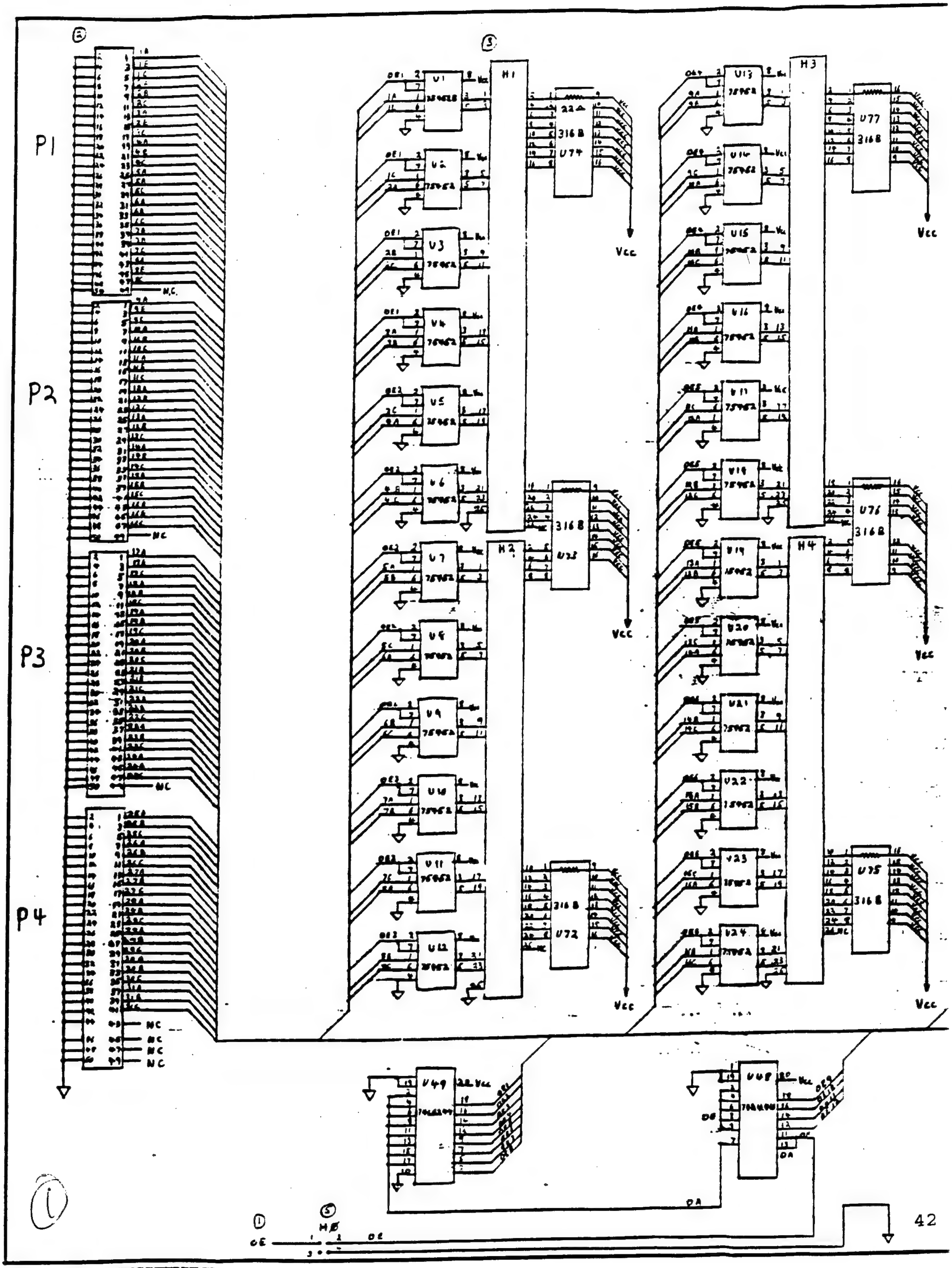
DNA-001-88-C-0083

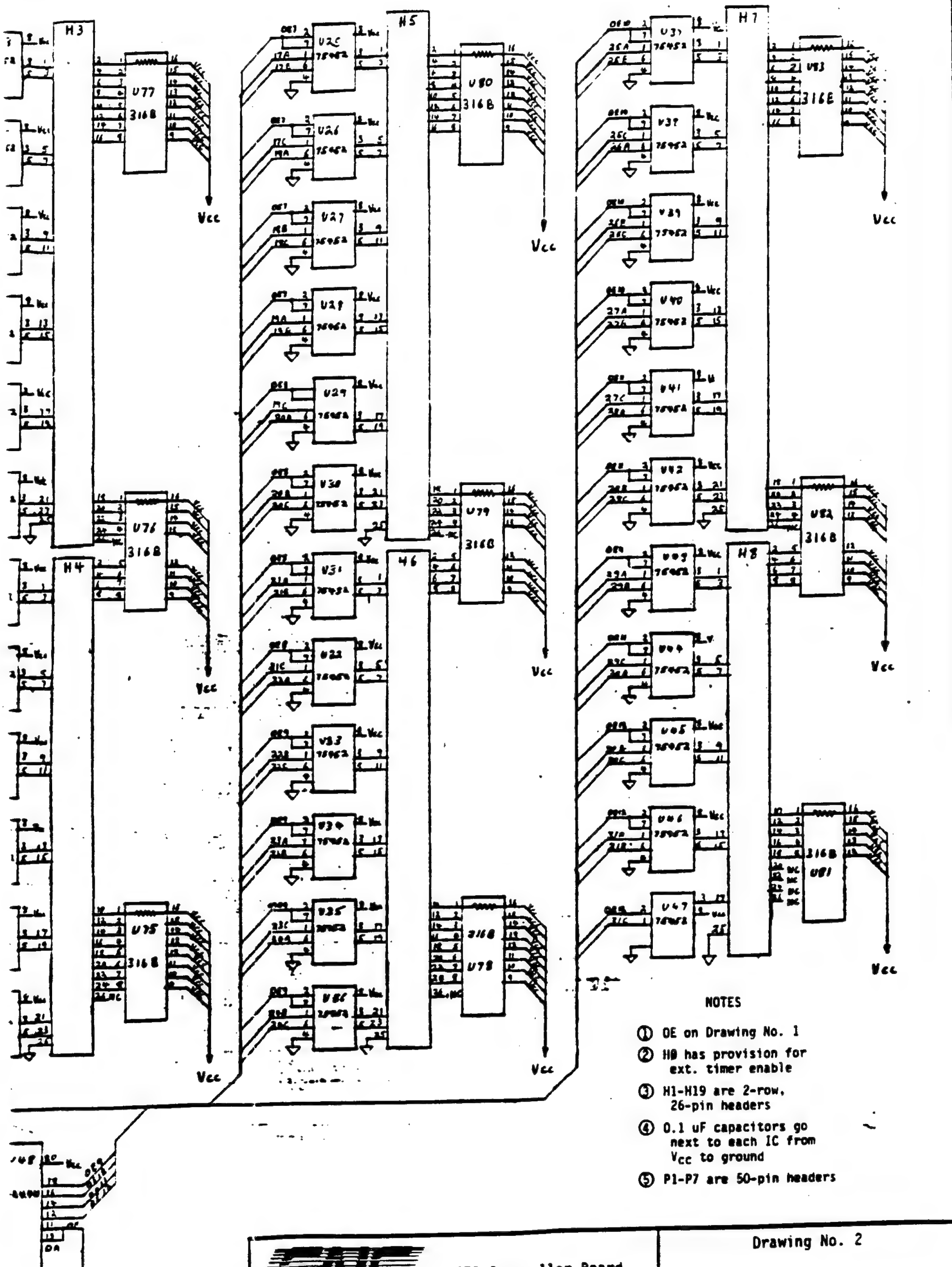
Science Applications International Corporation

Drawing No. 1

Interface between DIO216 and: lamp status, stepper control, home indicator, system triggers, and VSAL signal

3


P1
P2
P3
P4
H1
H2
H3
H4
U74
U77
U76
U75
U72
3168
Vcc
NC
OE
OA
HØ



NOTES

1. OE on Drawing No. 1
2. H0 has provision for ext. timer enable
3. H1-H19 are 2-row, 26-pin headers
4. 0.1 uF capacitors go next to each IC from V_{cc} to ground
5. P1-P7 are 50-pin headers

SAIC

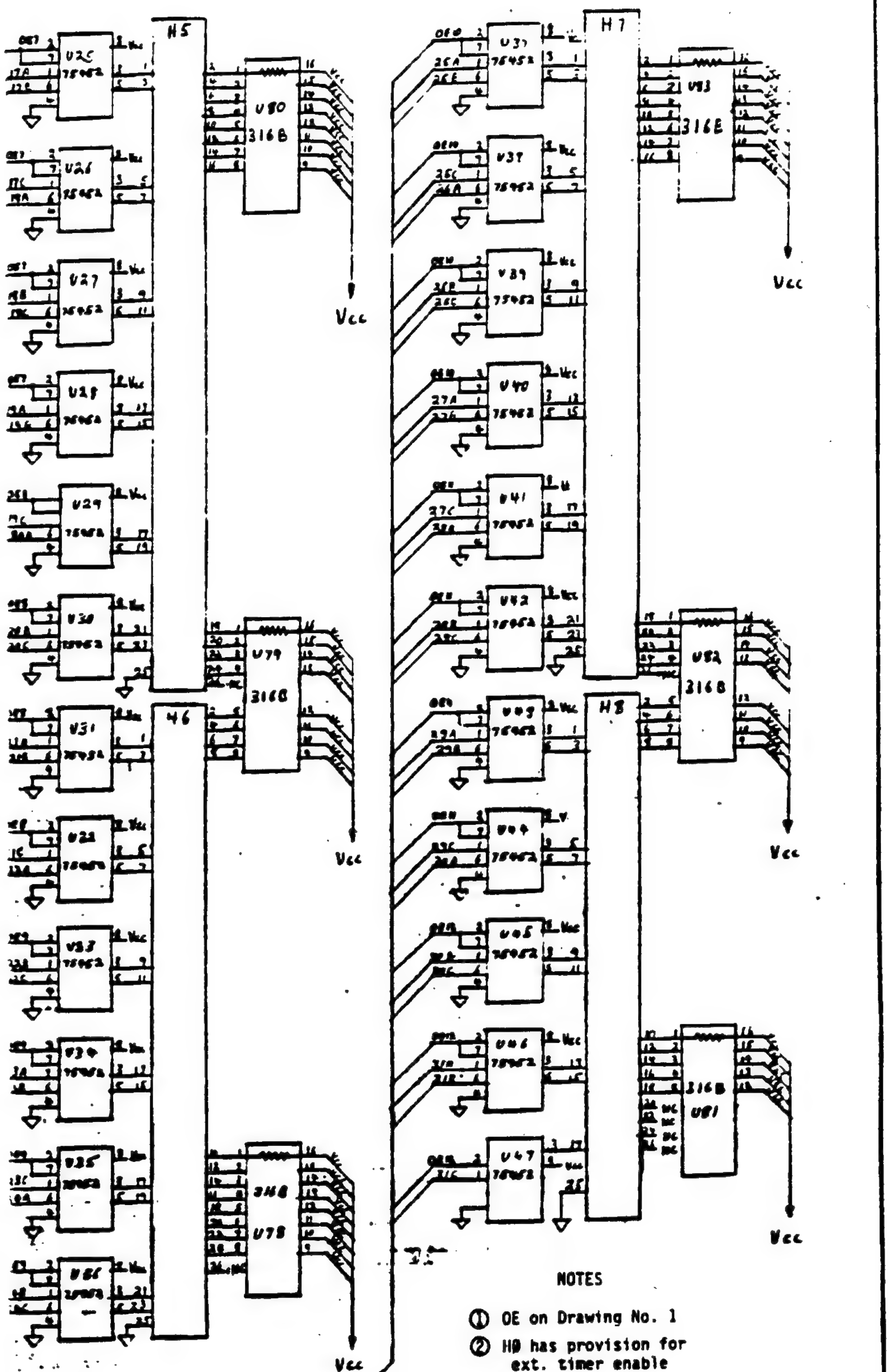
FTS Controller Board

DNA-001-88-C-0083

Science Applications International Corporation

Drawing No. 2

Interface between DIO216 and ignitron trigger circuits



NOTES

① OE on Drawing No. 1

② H9 has provision for ext. timer enable

③ H1-H19 are 2-row, 26-pin headers

④ 0.1 uF capacitors go next to each IC from V_{cc} to ground

⑤ P1-P7 are 50-pin headers

SAIC

Science Applications International Corporation

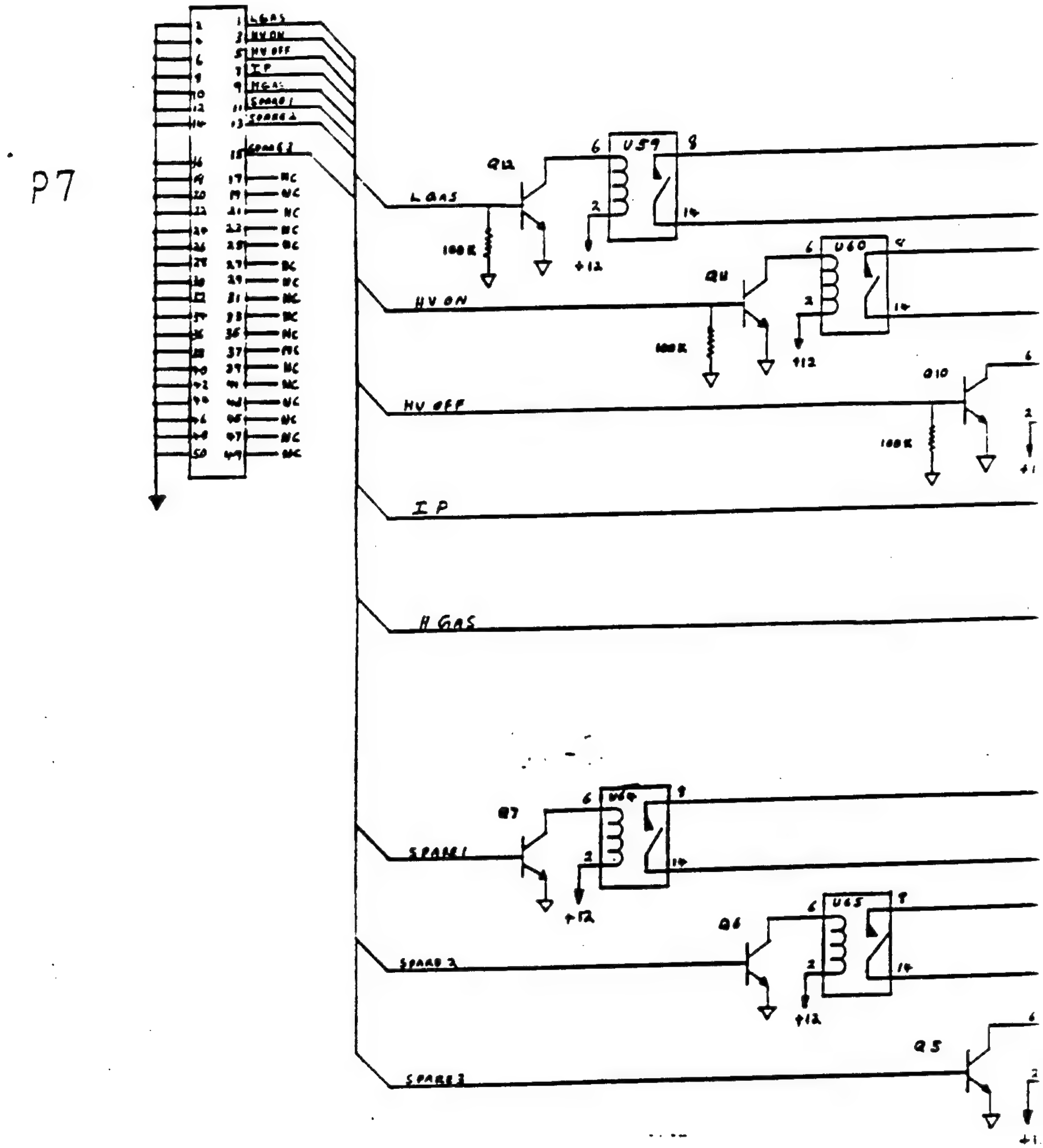
FTS Controller Board

DNA-001-88-C-0083

Drawing No. 2

Interface between DIO216 and ignitron trigger circuits

3

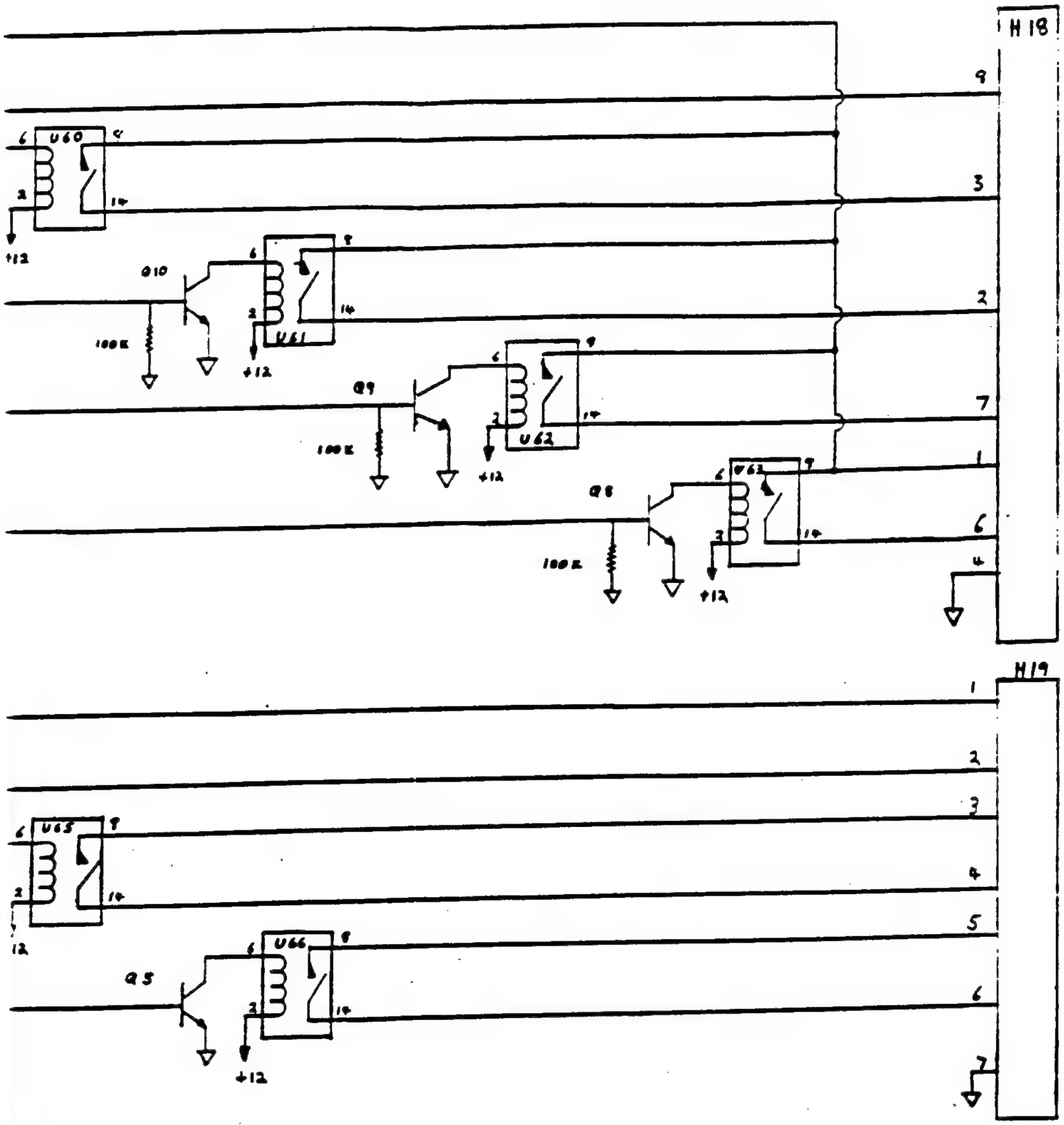


NOTES

① All unmarked pins on H18, H19 are

② Q5-Q12 are 2N3904 transistors

③ U59-UG6 are 17 DIP-9 reed relays with diodes



IOTES

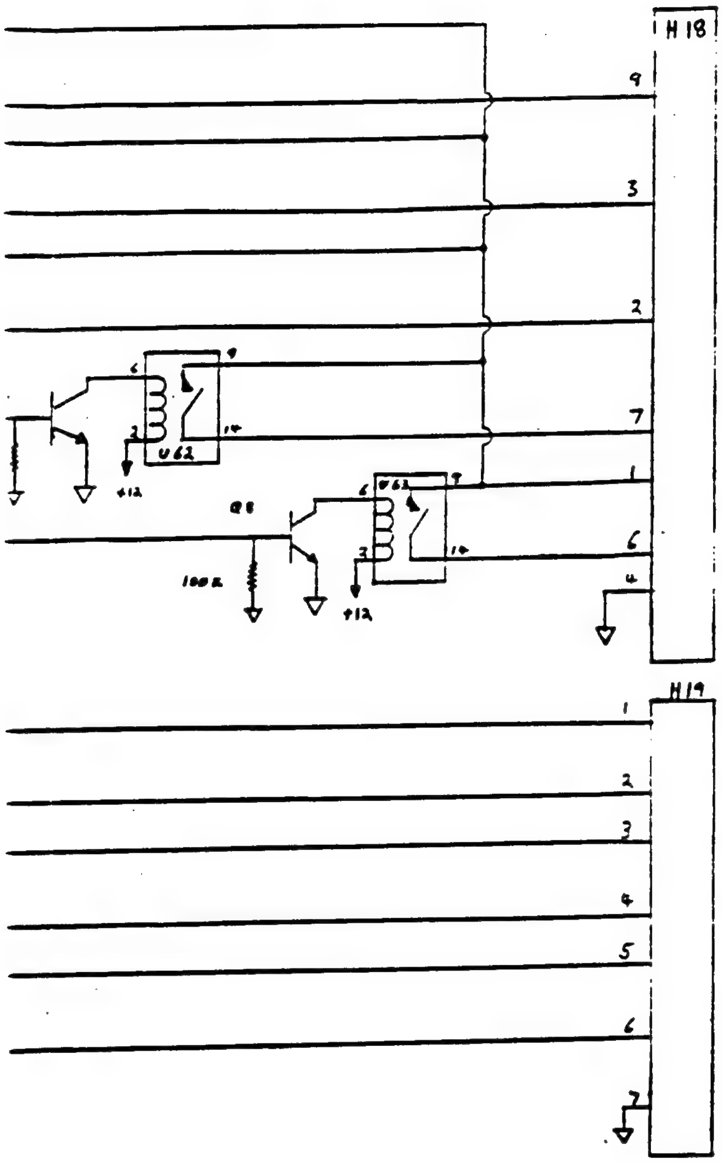
pins on H18, H19 are N.C.

13904 transistors

.7 DIP-9 reed relays

SAIC FTS Controller Board DNA-001-88-C-0083	Drawing
Science Applications International Corporation	Automated relay

6)



SAIC FTS Controller Board DNA-001-88-C-0083 Science Applications International Corporation	Drawing No. 3 Automated relay control circuits

83

SECTION 3

AUTOMATIC 3-PARAMETER PULSE SHAPING

The automatic 3-parameter waveform can be selected as an alternative to the MORE code operation. When Calculate nuclear waveform is selected from the Main menu, Calculation Choices will be displayed as in Figure 3.1. Select number 2-Automatic 3-parameter waveform and Figure 3.2, Pulse Parameters will be displayed. Peak flux, time to peak flux, and total fluence may be entered.

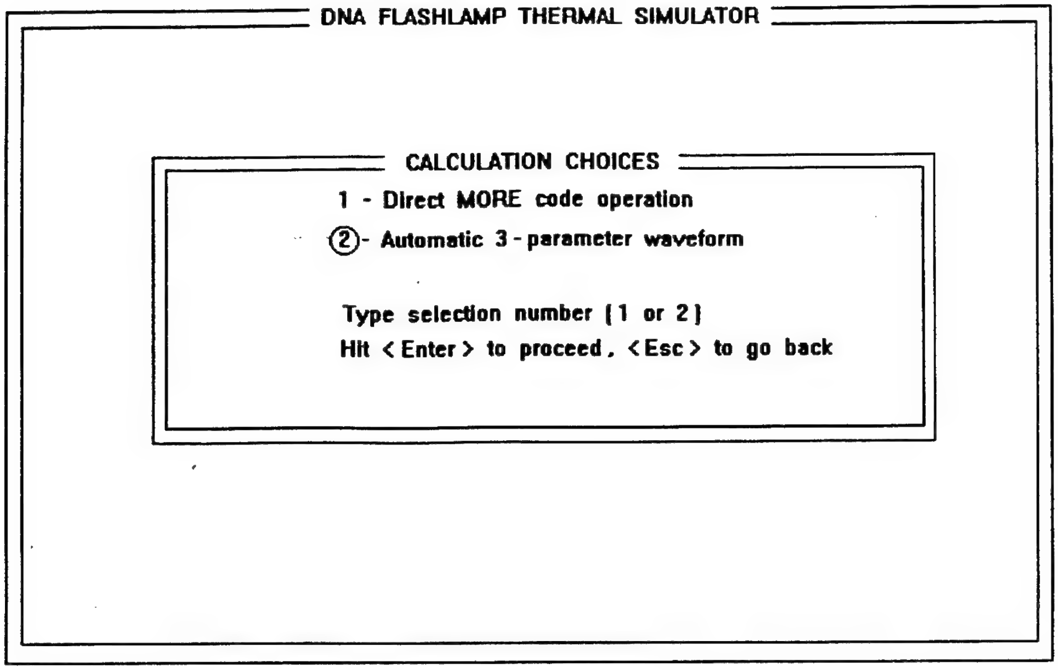


Figure 3.1. Calculation Choices.

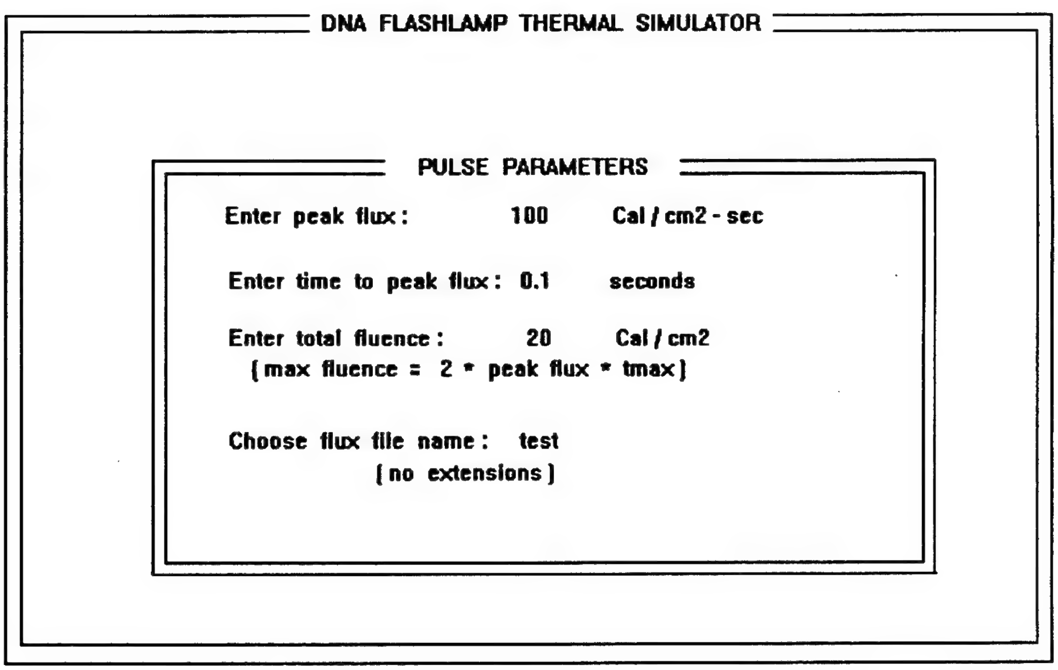


Figure 3.2. Pulse Parameters.

SECTION 4

SYSTEM DATA SET-UP AND VOLTAGE MONITORING

Setup for voltage monitoring using the Apple IIe:

1. Ensure Macsym 20 in on. (Look for light on its front panel.)
2. Insert ASCII Express for voltage Monitoring into disk drive #1.
3. Turn on Apple IIe monitor and computer.
4. At the "AE: TERM-->" hit space bar then press **ENTER**.
5. At the prompt type **CFG4**; then press **ENTER**.
6. Type **1:** then press **ENTER**.
7. At **01.** press **Control, Q** then **S**.
8. At **Filename** type **PARTONE A.ANALOG**; then **ENTER** 4 times. Wait for prompt!
9. At the prompt type **2:** then press **ENTER**.
10. At **02.** press **Control, Q** then **S**.
11. At **Filename** type **PARTTWO A.ANALOG**; then **ENTER** 4 times. Wait for prompt!
12. At the prompt press **Control, Q** then **R**.
13. At AE: COPY ON
AE: Term --> type **#1** then press **ENTER**.

14. FOR A HARD COPY OF LAMP BANK VOLTAGES.
    a. Press **Control, Q** then **R.** (This turns off the copier.)
    b. Type **Control, Q** then **Y**.
    c. Type **.O** for a hard copy.
    d. After you receive a hard copy type **.C** then **ENTER** answer **Y (yes)**
    e. Type **.X**; at the +> sign type **R**.
    f. The operator is ready to collect the lamp voltage data again.

SECTION 5
SERVICING

There is no main safety disconnect for the Flashlamp Thermal Simulator (FTS) but power can be cut to the capacitor charging system by opening circuit breakers 37, 39, and 41 on panel LP2 (Figure 5.1) behind the false wall or by pulling the large plug (208V, 30, 50A) on the wall above the control console in the FLS control room. Note that neither of these actions in themselves will render the capacitor bank SAFE.

Access to the capacitor banks for repair or maintenance is limited to authorized, trained Facility personnel. An observer must be present when any work is performed on any part of the capacitor bank system or inside the Flash-Head cabinet. The observer must stand clear of all cabinet, frame, or other structures and must keep the accessing individual in sight at all times. The observer must be trained in the technique of cardiopulmonary resuscitation (CPR) and have available to him a grounded gaff with wooden handle to be used to separate the accessing individual from high voltage if necessary.

When accessing the inside of any capacitor bank or inside the Flash-Head cabinet, the accessing individual will refrain from wearing finger rings, metal watches or bracelets, metal neck adornments, and metal belt buckles. Tools will not be carried in pockets when they protrude from the pocket. Pens or pencils will be removed from breast pockets.

Before accessing the capacitor bank area the bank discharge relays must be activated for a minimum of 10 minutes. Before accessing a capacitor drawer, the output line must be jumpered to ground using a suitable grounding strap and finally the capacitor to be accessed will be shorted using a suitable jumper across its terminals.

When servicing the Vortek Stabilized Arc Lamp (VSAL), the main disconnect (Figure 5.1) must be pulled down to its OFF position. Great caution must be exercised when working on the VSAL and components should always be shorted to ground before touching, because inductors in the system are capable of holding a charge of electricity even though the main disconnect has been pulled OFF. The "Two-Man" system is mandatory, whereby one man is performing the necessary service while a second man, trained in CPR, observes and is prepared to take action to clear the first man of harm by body-block or grounding pole. Eye protection in the form of safety glasses, goggles, or

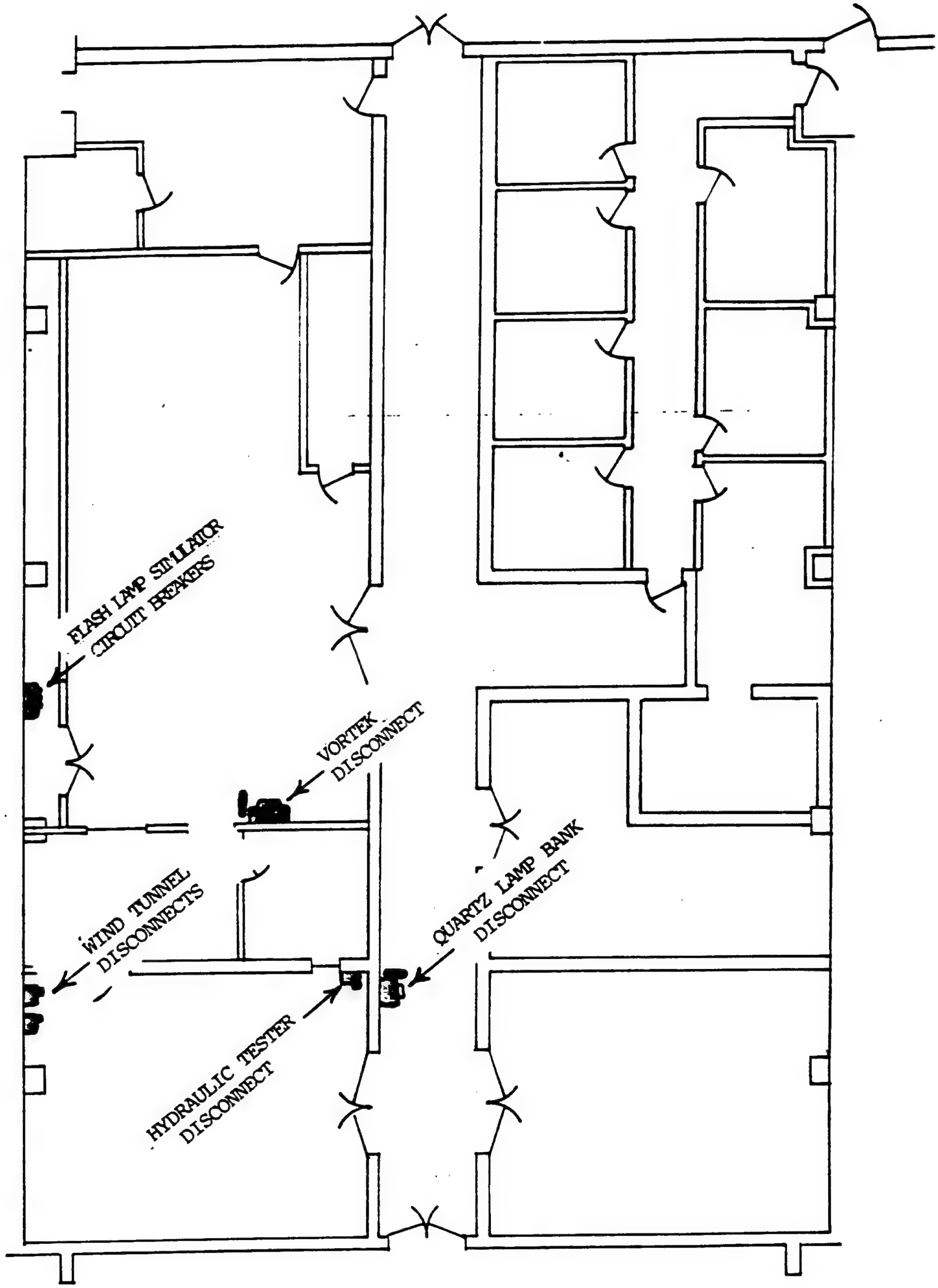


Figure 5.1. Disconnects.

face shields is to be worn by both men. Cooling water could be present on the floor around the VSAL creating a slippery footing condition. Hoses and cables create a possible tripping hazard and caution is advised.

<u>Gas Bottles</u>

Gas bottles will be moved only by trained, authorized Facility personnel and representatives of the supplier. Facility personnel will move only one bottle at a time when no cart is available; two bottles on a two-bottle cart only. Bottles will be stored in a special area where they may be properly secured in an upright position. When in storage, bottles may be grouped without securing each bottle individually but the group must fill the storage area with no open areas into which a bottle could lean or fall. When bottles are put on-line, each bottle will be secured by a chain attached to the wall and wrapping fully around the bottle at a point two-thirds of the bottles height.

Leather palm or other special bottle-handling gloves should be worn when moving gas bottles to improve grip and lessen possible damage to fingers or hands. Leather or safety shoes should be worn when moving gas bottles. Canvas or other soft-sided shoes such as tennis shoes or sneakers are not recommended wear for the manipulation of gas bottles.

Connecting/disconnecting gas bottles will be accomplished only by trained authorized Facility personnel. Eye protection in the form of safety glasses, goggles, or face shield must be worn when changing bottle fittings.

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